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(54) IMPROVEMENTS IN OR RELATING TO FOAM TUBES

(71) We, DYNAMIT NOBEL AKTIENGESELLSCHAFT, a German Company of 521 Troisdorf bez Koln, Postfach 1209, Germany, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to a method of forming a tube from a strip of heat softenable deformable foam, and to an apparatus for carrying out the method.

Tubes of foam, thin-walled or thick-walled and with small or large diameters, are used in particular for insulation against cold or heat. For example such tubes may be used for entire sanitary installations comprising hot water pipes, cold water pipes, waste water pipes, heating pipes and refrigeration pipes. Tubes of this kind may be directly extruded from foam. However, it is also possible to produce them from strips of foam. This applies in particular to foams of the type which cannot be directly extruded, such as crosslinked polyethylene foams. In this case, the strip of foam is produced in sheet form either by extrusion with after foaming or by spread coating, as is the case for example with flexible polyvinyl chloride foam.

It is known to us in Germany that tubes can be produced from strips of deformable thermoplastic foams by bending the strips of foam down and folding them flat together, the butt joint being welded or bonded. The hollow cross-section thus formed is then fixed. Unfortunately, the tubes produced in this way do not have a round cross-section, but instead an oval cross-section, which is a disadvantage especially in cases where, when the tube is subsequently slotted as an assembly aid, the slotted seam comes apart, that is, is non-form-locking. In addition, the method leaves residual stresses in the tube which lead to the danger that the bonded or welded seam may be forced apart again if it is not form-locking.

According to one aspect of the invention there is provided a method of forming a tube from a strip of heat softenable deformable foam, which method comprises

(a) heat softening a first surface of the strip;

(b) shaping the strip into a tube having said first surface as its inner surface and a second surface opposite to the first surface as its outer surface, and having an unsealed butt joint;

(c) cooling the shaped strip;

(d) sealing the butt joint;

(e) heating softening the second surface; and

(f) cooling the thus formed tube.

The two heat softening treatments, which substantially correspond to a tempering operation, are preferably carried out in such a way that, in each case, the heat penetrates through only part of the thickness of the cross-section of the strip, the resulting softening only being taken to such an extent that the structure of the foam is not destroyed. Both the heating temperature and the heating time are governed by the material of which the foam consists, for example flexible polyvinyl chloride or crosslinked or un-crosslinked polyethylene and also by the thickness of the foam. The heat softening treatments carried out in accordance with the invention result in the formation of a substantially stress-free tube which, even when it is subsequently cut open (longitudinal slotting), no longer has any tendency to return to its original strip form. In addition, it is possible by carrying out the method according to the invention to form even relatively rigid foams into tubular structures with relatively small internal diameters and to obtain thick walls in the case of small-diameter tubes.

According to one embodiment of the method according to the invention, the strip of foam, having been heat softened and shaped, is passed through and at the same time cooled in a forming tube. Thus the first heat treatment not only makes the first surface, that is the subsequent inside of the tube, substantially stress-free, but it also facilitates shaping into the cross section of the tube. After shaping into the tube cross-section, tube is preferably simultaneously cooled (hardened) and passed through a mould and is so rendered dimensionally stable. The shaped tube which has been hardened by cooling is preferably pressed into an oval cross-section, the long elipse axis extending horizontally and the butt joint to be sealed by for example welding or bonding being situated at the upper end of the vertical short elipse axis. Satisfactory contact of the butt joint along its entire surface is made possible in this way, thus enabling a satisfactory bond to be established.

Since the heat softening of the first surface carried out in accordance with the invention results in a softening of the strip of foam, it is preferred that the strip of foam be continuously moved by a conveyor belt having a rough surface until the butt joint is sealed, the strip of foam adhering to the rough surface. In this way, the strip of foam is prevented from being extended or stretched and uniform transport is promoted.

After the tube has been sealed along the butt joint, its outer surface is subjected to a heat softening and thereafter cooled. It is then preferably slotted at a point which does not form the butt joint, again in the longitudinal direction. In order to close this slot, a slide fastener or an overlapping adhesive tape may be arranged on the tube. The tube thus produced may be used with advantage for insulation purposes, the slot representing an assembly aid and the fastenings provided enabling the tube to be readily closed after assembly.

According to another aspect of the invention there is provided an apparatus for forming a tube from a strip of heat softenable deformable foam, which apparatus comprises

(a) a means for conveying the foam along a path;

(b) a first heating means adjacent said path for heat softening a first surface of the strip of foam as it is conveyed along the path;

(c) a shaping means adjacent said path for forming the strip into a tube which has an unsealed butt joint and said first surface as its inner surface and a second surface, opposite to said first surface, as its outer surface;

(d) a first cooling means adjacent said path for cooling the shaped strip;

(e) a sealing means adjacent said path for sealing the butt joint;

(f) a second heating means adjacent said path to heat soften said second surface; and

(g) a second cooling means adjacent said path for cooling the formed tube.

Preferably the conveying means comprises a continuously circulating belt with a rough surface for transporting the continuously delivered strip.

The shaping means preferably comprises a shaping funnel and a shaping tube which is preferably equipped with, that is in conjunction with, the first cooling means. In one embodiment the shaping tube is formed with a guide slot in it s upper surface, at least at its inlet and outlet ends, by the introduction of a guide rail, into the butt joint of the shaped tube.

Preferably the sealing means includes a contact-pressure generating unit and a device for sealing the butt joint, for example by welding or bonding. The contact-pressure generating unit may be for example, hold-down plates, for converting the tube into an oval cross-section, these being provided in the vicinity of the device for sealing the butt joint, for example a heating lance. In this way, the mating surfaces of the unsealed butt joint may be urged together, that is brought satisfactorily into contact with one another, and a lateral pressure applied to the butt joint.

The second heating means which acts on the second surface, that is the outside of the tube, is followed by a second cooling means. In addition, the apparatus is preferably provided with a cutting blade for slotting the heat treated and cooled tube, so that the finished, ready-to-use tube is obtained in the required length on completion of the continuous manufacturing process.

For a better understanding of the invention, and to show how the same may be carried into effect, reference will now be made, by way of example, to the accompanying drawings, in which:—

Figures 1A and 1B diagrammatically illustrate an apparatus according to the invention;

Figure 2 is a diagrammatic cross-section through the first heating means on the line A-A of Figure 1A;

Figure 3 is a diagrammatic view of a shaping tube in section on the line B-B of Figure 1A;

Figure 4 is a diagrammatic view through a sealing means in section on the line C-C of Figure 1A; and

Figure 5 is a diagrammatic view of a contact-pressure generating unit in section on the line D-D of Figure 1A.

Referring to Figure 1A, there are shown foam strips 2 of a heat softenable and

deformable material, each of which is wound in the form of a supply roll 1, and is processed into tubes. The strip 2 travels from the supply roll 1 by way of a guide roller 3 onto a work table 4 on which there is provided a splicing unit 5. This splicing unit 5 is required for joining the strips 2 together when the rolls are changed. From the work table 4 the strip 2 travels through a pair of guide rollers 6 where it runs onto an endless belt 8. The belt 8 takes over the transporting function for the strip 2. To this end, the belt 8 has a very rough surface formed for example by emery paper of any grain size. The belt 8 shows extremely good mechanical adhesion to the strip 2. This is important because during subsequent heat treatment, the strip loses mechanical strength and would otherwise be in danger of not being uniformly transported by the belt or even of being stretched. The endless belt 8 is passed through various units (7, 9-16 as described hereinafter) with the strip 2 and, after passing through a contact-pressure generating unit 20, is reversed and returned by way of a tension roller 17 back to the guide rollers 6. The endless belt 8 is driven by a drive roller 22.

After the strip 2 has run onto the belt 8 and is transported thereon, it passes through a first heating means in the form of a heating unit 7, a cross-section through which is shown in Figure 2. The heating unit 7 may be operated by using, for example, hot air or radiant heat. In use of the apparatus, on passing through the heating unit 7, the strip is heated on one side, this being the surface which subsequently forms the inside of the tube, and is converted into heat softened form. The heat applied only penetrates through the thick cross-section of the strip to such an extent that the reverse side which forms the outside of the tube remains more or less cold and unsoftened and enables the strip as a whole to be mechanically transported by and to adhere to the endless belt 8. The heating temperature and heating time are goverened both by the properties of the foam and by the thickness of the strip. In general it is desirable to heat the strip such that it becomes heat softened, that is to heat it until it changes into the thermoelastic or thermoplastic state, throughout substantially half its thickness. Under no circumstances should heat softening be allowed to go so far that the structure of the foam is destroyed.

The heat treatment which the strip undergoes on passing through the heating unit 7 substantiallly corresponds to a tempering operation. In this treatment, referring now to Figure 2, the belt 8 travels over workplate 13. The heating zone is screened off by lateral screening plate 9 so that the strip is uniformly heated within its central and peripheral zones.

After leaving the heating unit 7, the heated, partly plasticised strip 2 passes into a unit in which it is formed into a tubular cross-section having a butt joint. To this end, the strip 2 travels into a shaping funnel 10 which transforms it into a tube cross-section 2*a* (Figure 3). The shaping funnel 10 is directly adjoined by a shaping tube 14 which is provided in it upper surface with a guide slot 14*a*, at least at its inlet end and also at its outlet end, as can also be seen from the diagrammatic cross-section in Figure 3. Into this guide slot 14*a* there projects, at least in the inlet zone, a guide rail 12 which also projects into the butt joint of the strip formed into the tube 2*a* and marks it so that the shaped tube is prevented from rotating during its subsequent further transport. In addition, the shaping tube 14 is provided with a cooling unit 11, cooling air being blown into the shaping tube 14. This ensures that the strip shaped into the tube 2*a* is cooled to room temperature and hardened during its passage through the shaping tube 14. The belt 8 is also introduced into the shaping tube 14, as may be seen from Figure 3, and adapts itself to the curvature of the shaping tube so that the shaped tube 2*a* also applies a pressure to the conveyor belt 8 with the result that, in spite of the friction in the shaping tube, satisfactory transport takes place. The width of the belt 8 can be considerably narrower that the width of the strip 2, amounting for example to between a quarter and a third thereof. In the embodiment shown, guide rollers 16 are provided at the end of the shaping tube 14, although this is not absolutely essential and depends upon the foam tube to be produced. There is also provided a guide rail in the outlet zone as well, this guide rail projecting into the butt joint of the shaped tube 2*a* and preventing the tube from rotating. This is also of importance insofar as it ensures that the butt joint of the tube always leaves the shaping tube at the same place and can be delivered in this position to the following unit for sealing the butt joint.

The shaped tube 2*a* which still has an open butt joint is then subjected to further treatment to close the open joint, for example welding of the butt joint, bonding of the butt joint, welding on a slide fastener or wrapping the tube in a film having an adhesive surface so that the surface adheres to the tube in the region of the open butt joint and thus closes the joint. In the embodiment illustrated, there is shown a welding unit 19 for welding the butt joint of the shaped tube 2*a*, as can also be seen from the cross-section shown in Figure 4. In order to obtain satisfactory welding of the butt joint, the preformed tube 2*a* is guided between upper and lower hold-down plates 18*a* and 18*b*

respectively, which force the tube to assume an oval cross-section, the long elipse axis extending horizontally. The butt joint of the shaped tube 2*a* is situated on the top of the tube so that a heating lance 19 which is provided projects into the butt joint and heat softens the surfaces thereof so that they weld together to form a tube 2*b* having a sealed butt joint 35 (Figure 5). In addition, adjustable lateral guide supports 36 are provided as a lateral boundary. In this compressed, oval cross-sectional form, the tube 2*b* welded along the butt joint is directly introduced into the above-mentioned contact-pressure generating unit 20 which holds the tube in a predetermined position over a predetermined length until the weld seam has hardened. At the end of the contact-pressure generating unit, the belt 8 is separated from the tube 2*b* and returned to its starting point, whilst the tube 2*b* is further transported to a second heating unit 24 by means of guide rollers 23 (Figure 1B).

Figure 5 is a cross-section through the contact pressure generating unit 20 showing the oval cross-section of the tube 2*b* welded along the butt joint 35 and held on the one hand by an adjustable lateral boundary 21 and on the other hand by upper and lower belts 20*a* and 20*b* respectively of the contact pressure generating unit 20. The guide rollers 23 which follow the contact-pressure generating unit 20 may also perform the function of converting the oval tube back into round form by the application of lateral pressure.

As shown in Figure 1B , the guide rollers 23 are in turn followed by the second heating means in the form of a second heating unit 24 which carries out the extermal tempering of the tube 2*b*. On passing through the second heating unit 24, the tube is heated on its outer surface until its outer skin is softened, but only briefly so that the structure of the foam remains intact. The final stresses remaining in the outer layer of the tube are eliminated under the effect of this heat treatment so that the tube is not left with any stresses capable of forcing it back into its original form of a flat strip. Ater leaving the heating unit, the tube is cooled again, in the embodiment shown by passage through a cooling tube 27. The cooling tube 27 may b operated in the embodiment with cooling air introduced through an inlet 26. The cooling tube 27 is proceeded by a baffle 25 which ensures satisfactory delivery of the cooling air. The cooling tube 27 is replaceable and may be adapted in its diameter to the particular tubes to be manufactured.

The tube is further transported by take off rollers 29 which are driven via a drive means 31 and a pivotal drive roller 28 arranged over the tube. A cutting unit in the form of a rotating cutting blade 30 is arranged in this zone for longitudinally slotting the welded, heat-treated and hardened tube at a point which does not correspond to the butt joint. For cutting the slotted tube 2*c* to length, a guide 32, for example in the form of a guide sleeve, is provided, being followed by a cross cutting blade 33. After they have been cut to length, the tube sections are carried off for storage by way of a dumping unit 34.

By virtue of the method and apparatus according to the invention, it is possible to produce a substantially stress-free, form-locked tube from strips of foam which, when subsequently slotted, comprises a form-locking slot which, in subsequent application, may be for example bonded or bonded over on its outside or provided with a slide fastening, or solution-welded.

WHAT WE CLAIM IS:—

1. A method of forming a tube from a strip of heat softenable deformable foam, which method comprises

(a) heat softening a first surface of the strip;

(b) shaping the strip into a tube having said first surface as its inner surface as its outer surface opposite to the first surface and a second surface, and having an unsealed butt joint;

(c) cooling the shaped strip;

(d) sealing the butt joint;

(e) heat softening the second surface, and

(f) cooling the thus formed tube.

2. A method according to claim 1 wherein the heat softenable deformable foam is flexible polyvinyl chloride foam.

3. A method according to claim 1 wherein the heat softenable deformable foam is a polyethylene foam.

4. A method according to any one of the preceding claims wherein before sealing the butt joint, the shaped strip is cooled by means of an airflow.

5. A method according to any one of the preceding claims wherein the mating surfaces of the butt joint are brought into contact before the joint is sealed.

6. A method according to claim 5 wherein the mating surfaces of the butt joint are brought into contact by deforming the shaped tube into an elliptical cross-section with the joint arranged at one end of the short elliptical axis.

7. A method according to any one of the preceding claims wherein the butt joint is sealed by welding.

8. A method according to any one of claims 1 to 6 wherein the butt joint is sealed by bonding.

9. A method according to any one of the preceding claims which includes the additional step of cutting a slot in a longitudinal axis of the tube.

10. A method according to claim 9 wherein the slot is cut in the tube at a position remote from the sealed butt joint.

11. A method according to claim 9 or 10 wherein a slide fastening or an adhesive tape is provided to seal the slot.

12. A method according to claim 1 substantialy as hereinbefore described with reference to the accompanying drawings.

13. A tube whenever formed by the method according to any one of the preceding claims.

14. An apparatus for forming a tube from a strip of heat softenable deformable foam, which apparatus comprises

(a) a means for conveying the foam along a path;

(b) a first heating means adjacent said path for heat softening a first surface of the strip of foam as it is conveyed along the path;

(c) a shaping means adjacent said path for forming the strip into a tube which has an unsealed butt joint and said first surface as its inner surface and a second surface, opposite to said first surface, as its outer surface;

(d) a first cooling means adjacent said path for cooling the shaped strip;

(e) a sealing means adjacent said path for sealing the butt joint;

(f) a second heating means adjacent said path to heat soften said second surface; and

(g) a second cooling means adjacent said path for cooling the formed tube.

15. An apparatus according to claim 14 wherein the conveying means includes an endless belt having a roughened surface to support the foam as it passes along said path.

16. An apparatus according to claim 14 or 15 wherein the first heating means comprises a unit for directing hot air or radiant heat onto the first surface.

17. An apparatus according to claim 14, 15 or 16 wherein the shaping means comprises a shaping funnel and a shaping tube through which the foam is passed as it moves along said path.

18. An apparatus according to claim 17 wherein the shaping tube is provided with a guide slot for accommodating a guide member extending into the shaping tube to prevent rotation of the formed foam tube within the shaping tube.

19. An apparatus according to claim 17 or 18 wherein the first cooling means is in the form of a cooling unit provided in conjunction with the shaping tube for hardening the foam tube during its passage through the shaping tube.

20. An apparatus according to any one of claims 14 to 19 wherein the sealing means includes a contact-pressure generating unit for urging together under pressure the mating surfaces of the unsealed butt joint.

21. An apparatus according to claim 20 wherein the contact-pressure generating unit includes means for deforming the tube into an elliptical cross-section with the unsealed joint arranged at one end of the short elliptical axis.

22. An apparatus according to claim 21 wherein the means for deforming the tube comprises first and second spaced plate members located on opposite sides of the path to define a channel through which the formed tube passes as it moves along said path.

23. An apparatus according to any one of claims 14 to 22 wherein the sealing means additionally includes a heating lance for location between the mating surfaces of the butt joint to heat soften said mating surfaces.

24. An apparatus according to any one of claims 14 to 23 which additionally includes a longitudinal cutting blade adjacent said path for slotting the formed and heat treated tube.

25. An apparatus according to claim 1 substantially as hereinbefore described with reference to the accompanying drawings.

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1514369 COMPLETE SPECIFICATION
3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheet 1

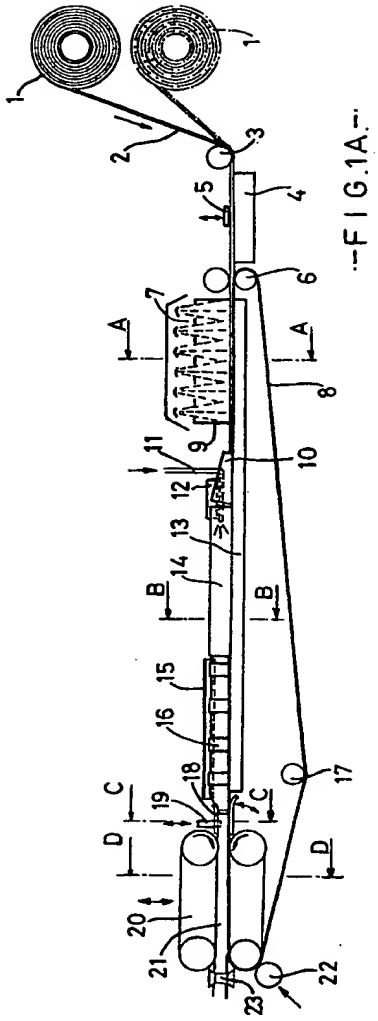

FIG.1A.

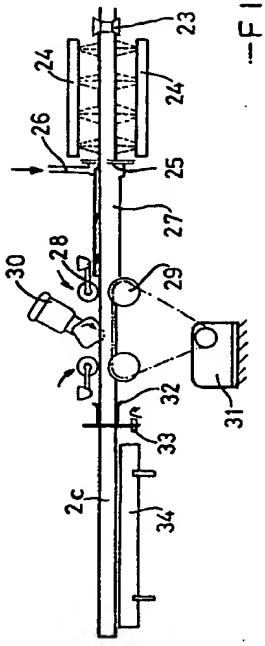

FIG.1B.

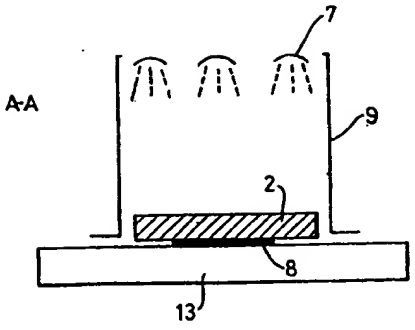

FIG. 2

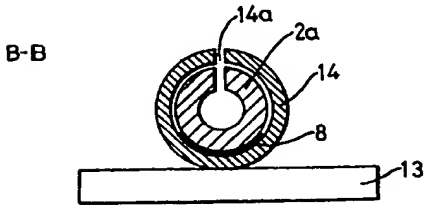

FIG. 3